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(81) Designated States: CH, DE, FR (European patent), JP, US.

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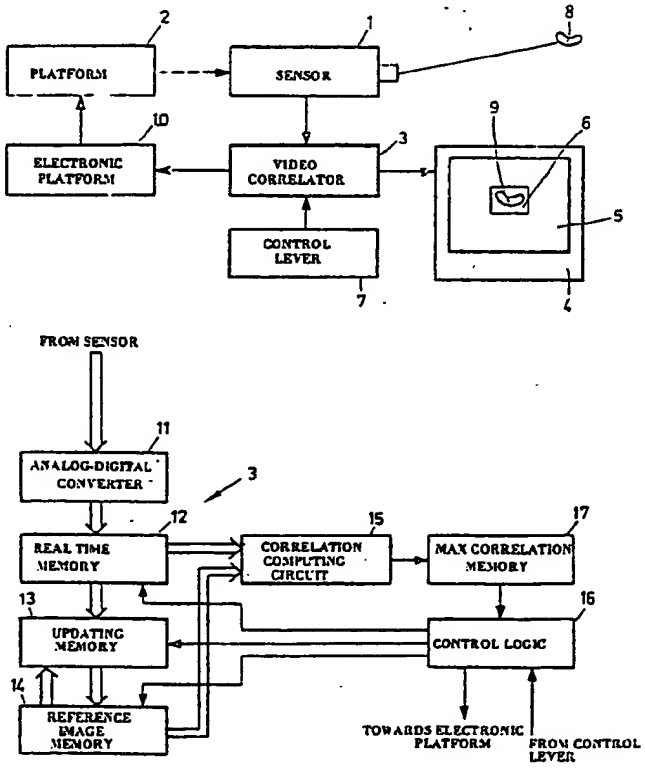
(54) Title: CORRELATION FOLLOWER FOR TRACKING AN OBJECT

(57) Abstract

A correlation follower comprising an image sensor (1) adjustable sideways and in height with a limited field of view, which is cyclically scanned by the sensor the output signal of which reflects the image content within the field of view and a video correlator (3) for controlling the alignment of the sensor in dependance of the output signal of the image sensor. The video correlator (3) has two addressable memories (12, 14) the one of which is a real time memory (12), i.e. in this memory a section of the field of view is stored for each cycle. The other memory is a reference image memory (14) and is updated with the content of the real time memory (12). During the correlation the contents of the memories are displaced in relation to each other and an error signal, corresponding to the position of displacement for which maximum correlation is achieved, is made to control, through said control circuits, the alignment of the sensor. To make the tracking process insensitive to disturbancies and image elements which appear momentarily in the field of view, for each scanning cycle only a part of the positions of the reference image memory (14) are updated by selecting the addresses to said positions randomly or according to a predetermined rule of selection. By that the positions which are updated during one cycle in positions are distributed over the entire area of the memory.



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Correlation follower for tracking an object

Technical field

The present invention relates to a correlation follower for tracking an object, comprising an image sensor having a limited field of view and arranged to scan said field of view cyclically and to supply, in preselected form, a video signal representing the field of view, a video correlator with two addressable memories, one of which has the object of storing in digital form for each scanning cycle one section of the field of view, while the other memory is arranged to be updated with the content of the first memory, said video correlator being arranged to produce, once the image sensor has been so aligned that an object is encompassed within the section, an error signal controlling the alignment of the image sensor with the object, said error signal corresponding to a displacement of the section in the first memory relative to the section in the other memory, for which displacement a maximum correlation is achieved between the contents of the memories.

Background art

By correlation one can get, according to a predetermined rule of evaluation, a measure of how well the contents of the memories coincide at different relative displacements.

Essential for the correlation and hence also for the tracking process is the way in which the other memory, subsequently referred to as the reference image memory, is updated. At known correlation followers, see e.g. US Patent No. 3 828 122, updating is brought about in the course of one single scanning cycle, either periodically the updating process being repeated after a certain number of cycles, or when the maximum correlation drops below a preselected value. If an image element irrelevant to the tracking process appears momentarily in the section the former updating alternative entails the danger of the reference image memory being updated precisely when the image element appears, which may jeopardise the tracking process. With the other updating

alternative the appearance of the image element may trigger updating of the reference image memory. This leads in practice to tracking of the irrelevant image element.

The object of the present invention is to bring about such updating of the reference image memory that the above disadvantages are avoided and this is enabled in that the video correlator has means arranged to select at each scanning cycle addresses of positions in the latter memory for the purpose of updating said memory randomly or according to a predetermined rule of selection so that said memory at each scanning cycle is updated only partly and in positions that are distributed over the area of the memory.

Description of the drawing

The invention is further explained below with reference to the attached drawing in which fig.1 is a block diagram showing schematically the design of a correlation follower, fig.2 is a block diagram showing the design of a video correlator and fig.3 is a block diagram showing how updating is effected according to the invention.

Description of a preferred embodiment

In fig. 1 an image sensor of known type and consisting of a TV or IR camera with a field of view restricted in space is designated 1. The sensor is mounted on a platform 2 capable of being adjusted both sideways and in height and is so designed as to scan the field of view cyclically and to supply a video signal which reflects the image content within the field of view in electric form. The video signal is supplied, via a video correlator 3 connected with the sensor 1, to a monitor 4 on screen 5 of which the sensor's field of view is displayed. A cursor is superimposed over the video signal in the video correlator 3, the position of which on the monitor screen 5 is shown as a window 6 which an operator can move, with the aid of a control lever 7, to any position on the screen. Also the size of window 6 can be varied with the aid of control lever 7 and the said size

so selected that the image 9 of an object 8 on screen 5 fits exactly within the window. In this way the effect of interference from the surroundings of the object can be minimised, i.e. irrelevant background contrasts are screened off. Using control lever 7 the operator can also align the sensor 1 with object 8 and get the correlation follower to lock on the latter. In this process aligning signals from control lever 7 are transmitted via the video correlator 3 to an electronic platform system 10 in which the aligning signals are converted into control signals for aligning the platform 2 and hence the sensor 1 both laterally and in height. After locking on, the sensor 1 tracks the movements of the object 8, whereby an error signal is extracted from the video signal of sensor 1 by means of a correlation process, which will be discussed in connection with fig. 2, the said error signal being converted in the electronic platform system 10 into control signals for aligning the sensor 1 as described above in connection with control lever 7.

In fig. 2 twin-line arrows illustrate a flow of image information. This flow of information reaches an analog/digital-converter 11 from an image sensor of the above described type which is not shown in the figure. The A/D-converter 11 is designed to convert an analog video signal from the image sensor, the amplitude of which corresponds to the contrast at each point within the field of view of the sensor, to a digital signal containing in binary coded form the same data as the video signal. A part of the digital signal corresponding to the said section of the field of view of the sensor is read, during each scanning cycle, into a memory 12, designated henceforth as the real time memory. The reason for the designation "real time memory" consists in the fact that the information stored in the real time memory in real time corresponds to the image content in the scanned section. From the real time memory 12 the flow of image information passes, on the other hand, via an updating date 13 to a memory 14, which is the above-mentioned reference image memory, and on the other hand to a correlation computing circuit 15 which also receives

image information from the reference image memory 14 forming an output from the latter. In the same way the designation "reference image memory" points to the fact that this memory is to serve as a reference during the correlation process. The flow of image information is controlled by a control logic 15 in accordance with the result of the correlation circuit measurement as will be described below.

As previously stated the image sensor can be made to lock on to the object, by means of the control lever 7. When this is the case the content of the real time memory 12 is copied, during one scanning cycle, into the reference image memory 14. In the course of each scanning cycle, i.e. with each image read into the real time memory 12, the contents of the two memories are compared in the correlation computing circuit 15, the said contents being placed in different positions relative to one another. The comparison may be effected in accordance with any known method of correlation by means of which a factor of merit is calculated for each relative position of the image information in the two memories 12, 14. The relative position in which the highest factor of merit, i.e. the maximum correlation, occurs, is stored in a memory 17. Depending on the relative position in which maximum correlation is achieved the control logic 16 controls the flow of image information, i.e. the correlation computing process and the updating of the reference image memory 14. The control logic 16 has also the object to regulate, in response to signals from the control lever 7, the arrangement of window 6 and to supply error signals to the electronic platform system 10.

Updating in accordance with the invention of the reference image memory 14 will now be explained with reference to fig. 3 in which as before twin-line arrows illustrate the flow of image information.

In fig. 3 which shows especially how the real time memory 12 and the reference image memory 14 are addressed and the latter memory

is updated, 18 designates an address counter by means of which partial elements in the memories 12, 14 are addressed sequentially via the address correction circuits 19 och 20, respectively, so that these are passed through line for line until all partial elements have been covered. The address correction circuits 19, 20 are controlled by memory 17, as regards the relative displacement between the contents of the memories at which the highest factor of merit is achieved as described above. The amplitude values in the partial elements addressed during this process in the respective memory are read into an amplitude logic 21 or a balancing circuit in which, according to a special characteristic of the invention, the amplitude values in corresponding positions are combined with one another, it being stated according to a criterion applying to each combination of amplitude values with which amplitude value the addressed position in the reference image memory 14 is to be updated. Such a criterion may be, for instance, that with quick or large changes in contrast, i.e. with large amplitude differences between the contents in the addressed partial elements, a mean value should be formed by means of which the partial element in the reference image memory is updated. This is equivalent to a certain filtration which prevents tracking of any image element which suddenly appears in the field of view. If the amplitude values in two corresponding positions are equal, updating will of course take place with this value, i.e. the content of the partial element in the reference image memory remains unchanged.

According to the primary characteristics of the invention updating shall occur randomly or according to a predetermined rule of selection so that during each scanning cycle the memory is updated only partly and in positions that are distributed over the area of the memory. This is achieved by that the amplitude value stated in accordance with the above criterion being fed to the addressed partial element in the reference image memory 14 via a gate 22 controlled by a prime or random number generator 23. With prime number generation the control operates in such a way

as to ensure that the gate 22 is opened for each p-th of the partial elements addressed by the address counter 18, p being a prime number the size of which is selected with a view of the required updating rate. Should p be set to 1 this would mean that the entire reference image memory 14 would be updated during one single scanning cycle as described above. Therefore the prime number is at least equal to 3. With random number generation the gate 21 is opened once the address counter 17 has counted forward s partial elements, s being a random number, e.g. from a table of random numbers. Whenever the gate 21 is opened a new random number is supplied. In this case the updating rate varies owing to selection of different mean values for the table of random numbers.

By that the updating is carried out according to the invention and thus is neither related to the result of the correlation nor carried out periodically, it is achieved that with great probability the reference image memory will not contains disturbing image elements and such that suddenly occur in the field of view of the sensor. This means that a correlation follower, the updating of the reference image memory of which is carried out as described above, is difficult to disturb and therefore the tracking of an object can be carried out with high accuracy.

It is obvious that the invention can be modified in many ways within the scope of the inventive idea. It is possible, for instance, to utilize the video signals from a radar station for tracking an object. Further the updating may be carried out according to some other rule of selection than described above, e.g. according to a fixed pattern that is moved successively over the area of the memory.

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Claims

1. A correlation follower for tracking an object, comprising an image sensor having a limited field of view and arranged to cyclically scan said field of view and to supply, in a preselected form, a video signal corresponding to the field of view, and a video correlator with two addressable memories one of which has the object of storing in digital form for each scanning cycle a section of the field of view while the other memory is arranged to be updated with the contents of the first memory, said video correlator being arranged to produce, once the image sensor has been so aligned that an object is encompassed within the section, an error signal controlling the alignment of the image sensor with the object, said error signal corresponding to a displacement of the section in the first memory relative to the section in the other memory for which displacement a maximum correlation is achieved between the contents of the memories, c h a r a c t e r i s e d in that the video correlator (3) has means (21, 22) arranged to select, for the purpose of updating the other memory (14), addresses of positions in the latter memory randomly or according to a predetermined rule of selection so that the other memory (14) for each scanning cycle is updated only partly and in positions that are distributed over the area of the memory.

2. A correlation follower according to claim 1, c h a r a c t e r i s e d in that, the video correlator (3) is arranged to select the addresses to the positions of the memory for the updating so that of addresses generated in a certain sequence each p-th is selected where p is a prime number.

3. A correlation follower according to claim 1, c h a r a c t e r i s e d in that the video correlator (3) is arranged to read while updating each selected position in the other memory (14), the contents stored in that memory and at the corresponding

position of the first memory (12), to combine the contents of the said positions with one another and to state, in accordance with the criterion applying to each combination of contents, with which value the selected position in the other memory (14) is to be updated.

1.

FIG 1

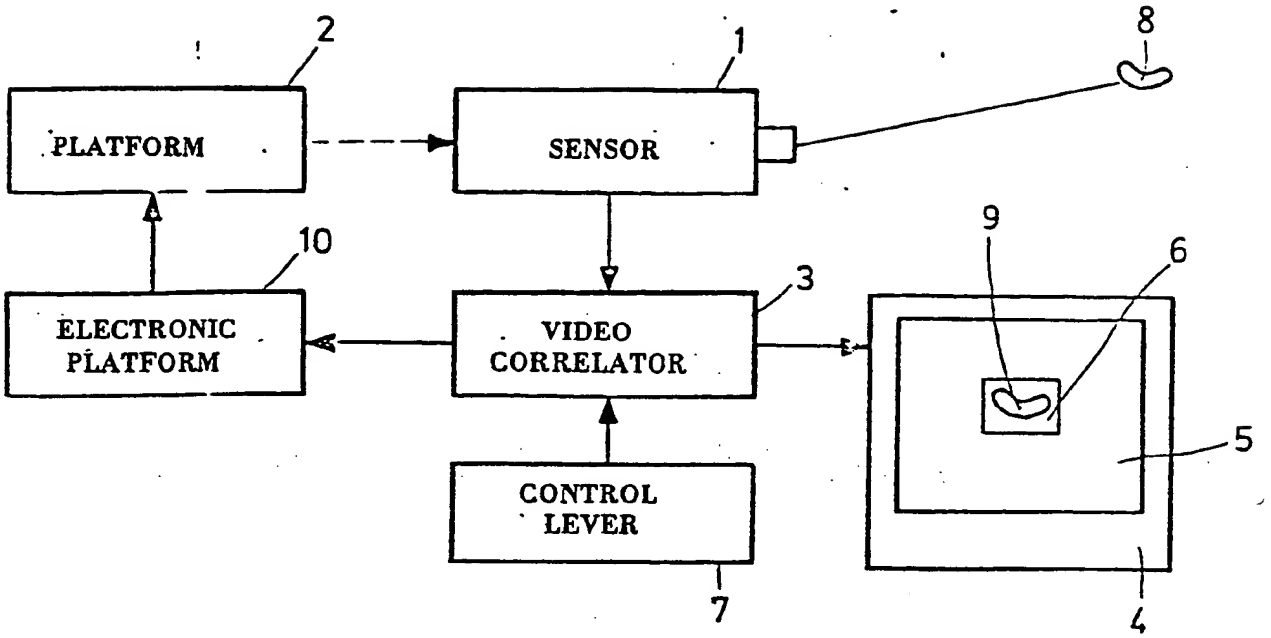


FIG 2

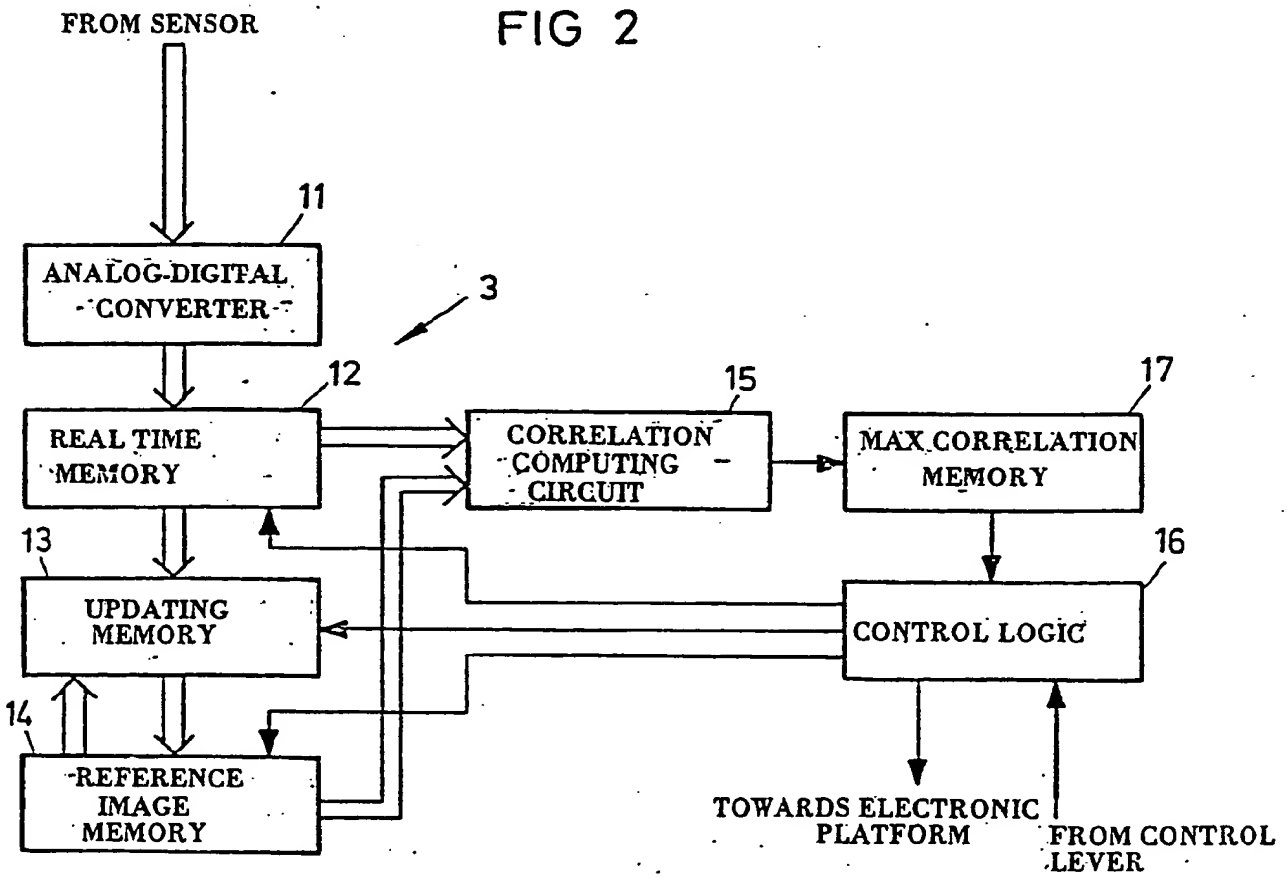
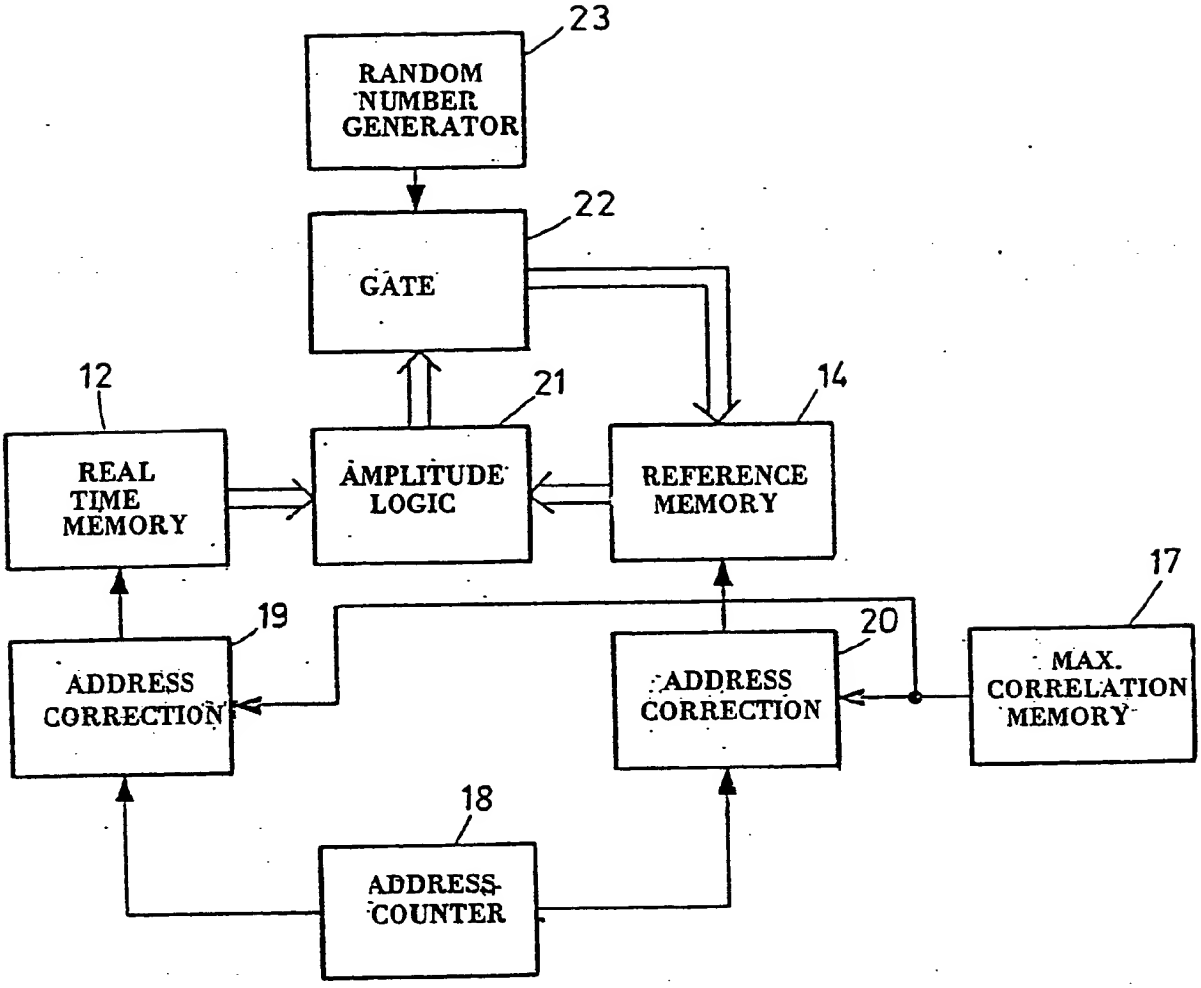


FIG 3



INTERNATIONAL SEARCH REPORT

International Application No PCT/SE78/00067

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

G 01 S 3/78, G 01 S 7/46, H 04 N 7/18

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC 2	G 01 S 3/78, 5/16, 7/46; G 06 F 15/34, 15/50; H 04 N 7/18, F 42 B 15/00-02 .../...

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [5]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	US, A, 3416752 published 1968, December 17, Martin-Marietta Corporation	
A	US, A, 3955046 published 1976, May 4, EMI Limited	

* Special categories of cited documents: [15]

"A" document defining the general state of the art

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"T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention

"X" document of particular relevance

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
1978-12-14	1978-12-19
International Searching Authority [1]	**Signature of Authorized Officer [20]**
Swedish Patent Office	Göran Magnusson

Form PCT/ISA/210 (second sheet) (October 1977)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

II Continuation classification system.

Deutsche Klassen: 42c:39/15, 39/20; 72d:19/10

US classification: 178-6.8, 235-61.5, 244-3.15, 3.16, 3.17, 358-125

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers_____, because they relate to subject matter [13] not required to be searched by this Authority, namely:

2. ☐ Claim numbers_____, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.